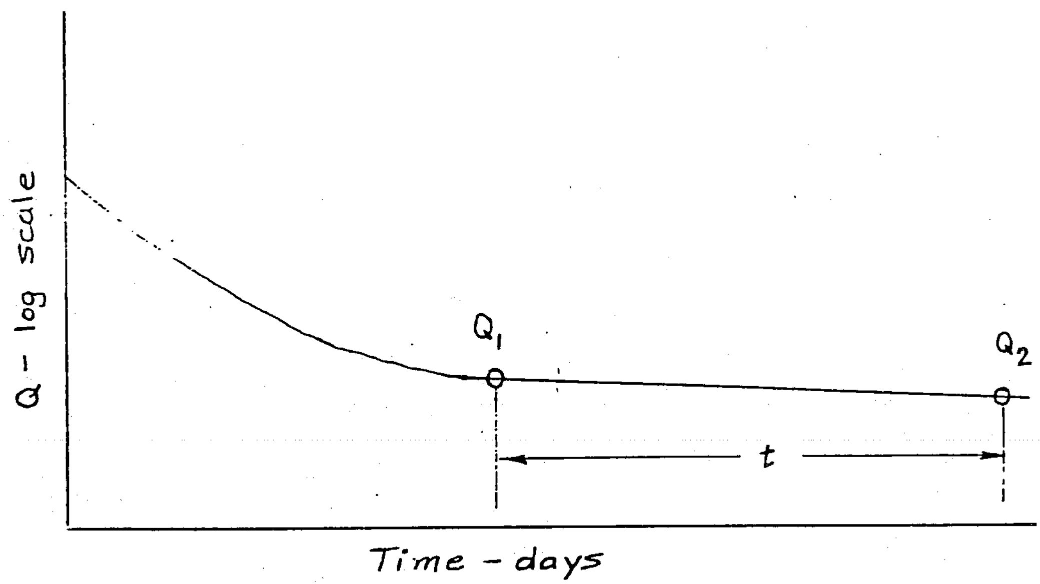
INITIAL SOIL-MOISTURE PARAMETER
ESTIMATES BY HYDROGRAPH ANALYSIS

I. Parameters for which good estimates can generally be obtained.

1. LZPK - minimum baseflow recession



recession rate $K_r = \left(\frac{Q_2}{Q_1}\right)^{1/t}$

$LZPK = 1.0 - K_r$

Things to consider:

a. ground melt in winter

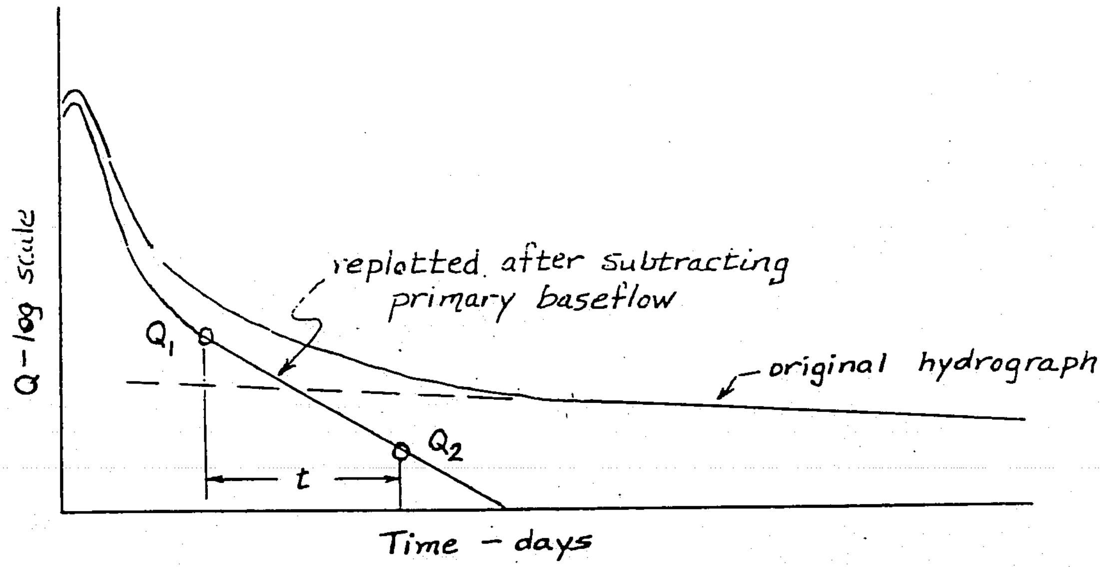
b. riparian vegetation ET in summer

c. extended supplemental recessions

d. reservoirs - diversions

e. variable primary recession

2. LZSK - supplemental baseflow recession (always > LZPK). Flow that typically persists anywhere from 15 days to 3 or 4 months.



recession rate $K_r = \left(\frac{Q_2}{Q_1} \right)^{1/t}$

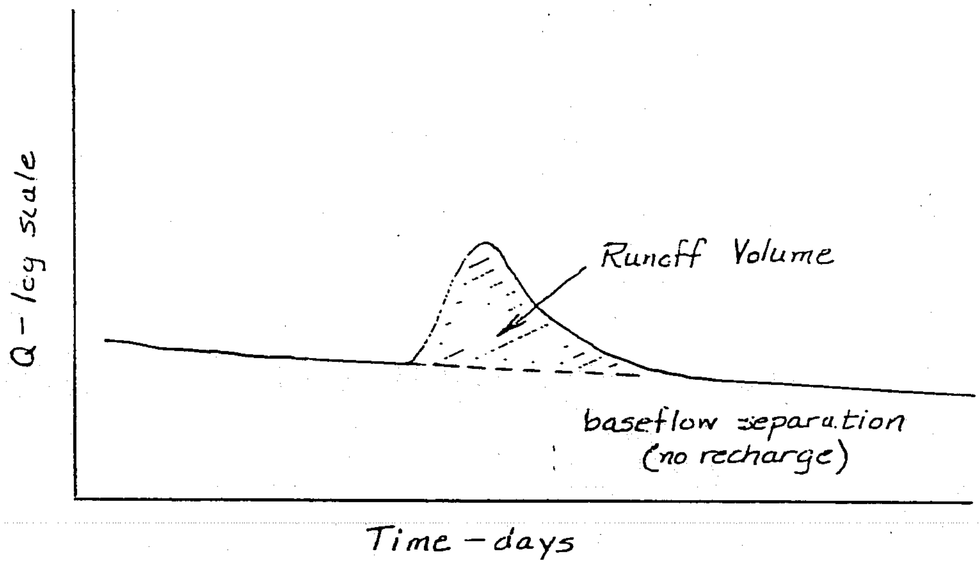
LZSK = 1.0 - K_r

Things to consider:

a. combination of supplemental and primary is not a straight line on semi-log plot.

b. better, but not necessary to replot with primary subtracted.

3. PCTIM - minimum impervious area. Only storm runoff that occurs when UZTWC not full.



Use small rise in summer following a week or more of dry weather.

PCTIM = Runoff Vol./Rain + Melt

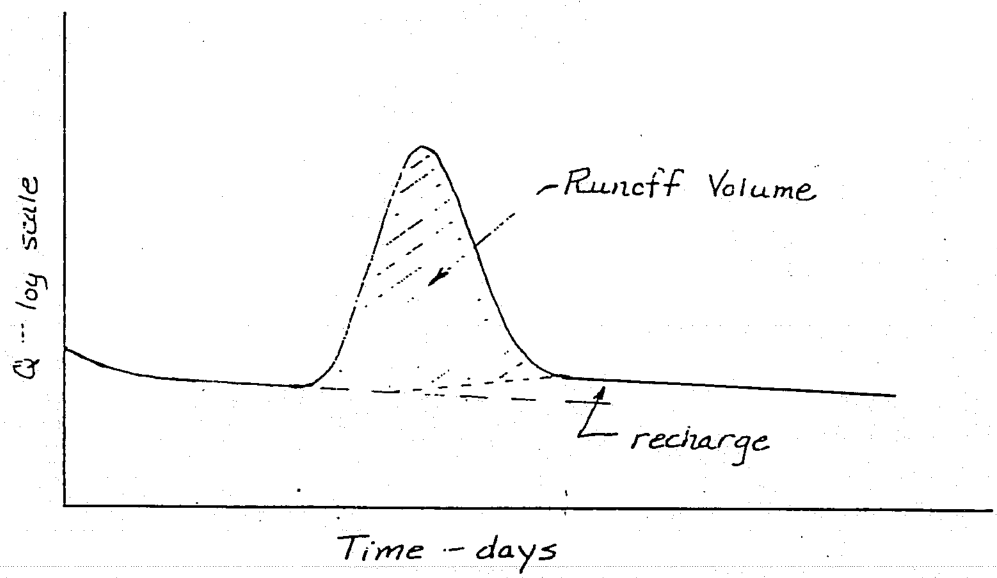
Things to consider:

a. use a number of events, take average of ones with the smallest PCTIM.

b. be aware of approximate magnitude of ET-demand.

c. derive in conjunction with UZTWM.

4. UZTWM - upper zone tension water capacity.



Use small or moderate rises in summer following dry periods which are long enough (usually 2 weeks or more) to substantially deplete upper zone moisture.

Criteria:

a. Runoff Vol./Rain + Melt > PCTIM

b. small amount of recharge occurs (not if PFREE very small)

UZTWM = amount of rain + melt needed to just meet the criteria.

Things to consider:

a. this is a minimum estimate of UZTWM

b. try several cases, use largest of the values (within reason)

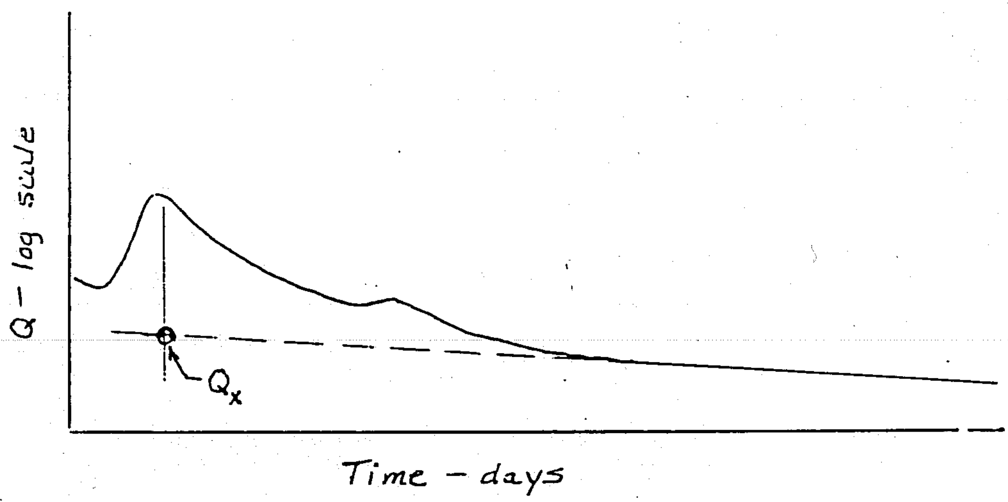
c. precipitation errors can be large since such rises are often associated with convective storms.

II. Parameters for which initial estimates can be computed though quality varies.

1. LZFPM - lower zone free water capacity.

Methods:

a. extension of recession



b. examination of semi-log plot. Search through semi-log plot and try to approximate the highest level of primary baseflow runoff that occurs. This is Q_x.

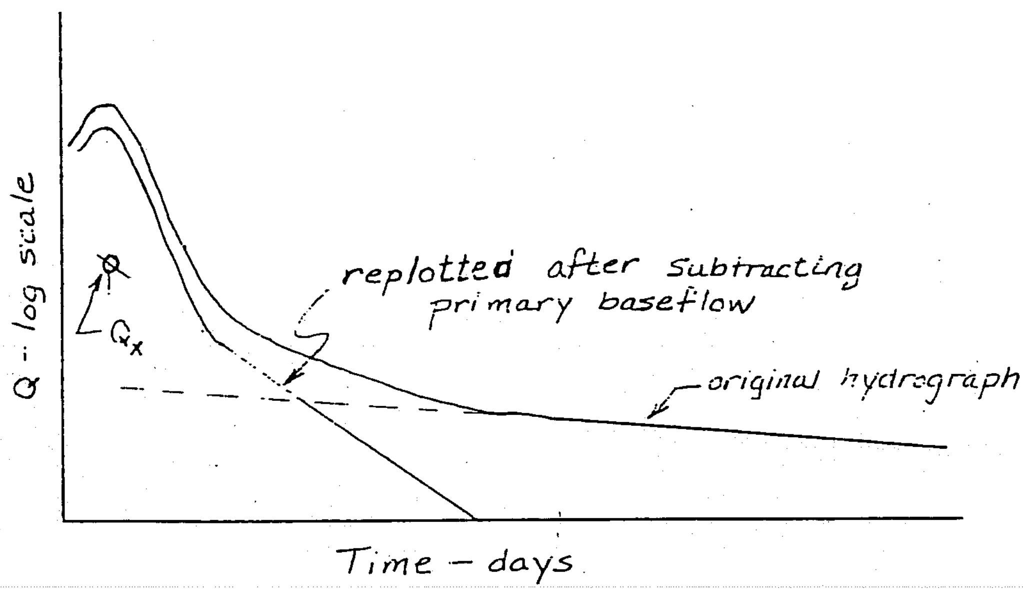
$LZFPM = Q_x/LZPK$

Things to consider:

a. this is a minimal estimate since LZFPC probably never equals LZFPM. Fills to 60 to 90+ % of capacity. Lowest percentage usually associated with most permeable soils.

b. further recharge normally occurs after Q_x.

2. LZFSM - lower zone free supplemental capacity.



$$LZFSM = Q_x/LZSK$$

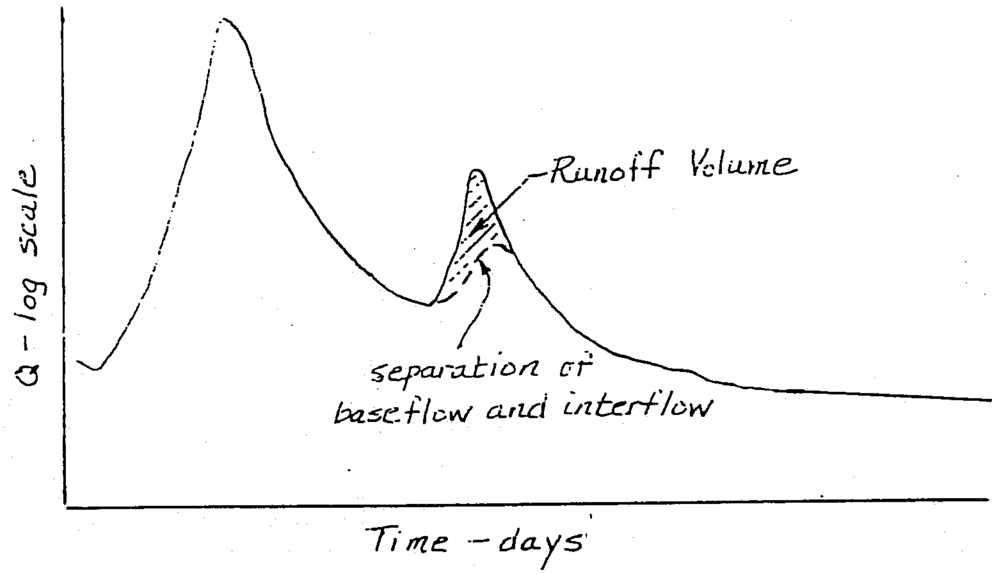
Things to consider:

a. better, but not necessary to replot with primary subtracted.

b. this is a minimal estimate since LZFSC never equals LZFSM. Reaches smaller percent of capacity than LZFPC. General rule - the larger LZSK, the smaller $LZFSC_{max}/LZFSM$.

c. further recharge frequently occurs if LZSK is less than about 0.05.

3. ADIMP - maximum size of variable impervious area.



Use moderate size event which peaks quickly, but contains no surface runoff and occurs when the soil is saturated (no tension water deficit).

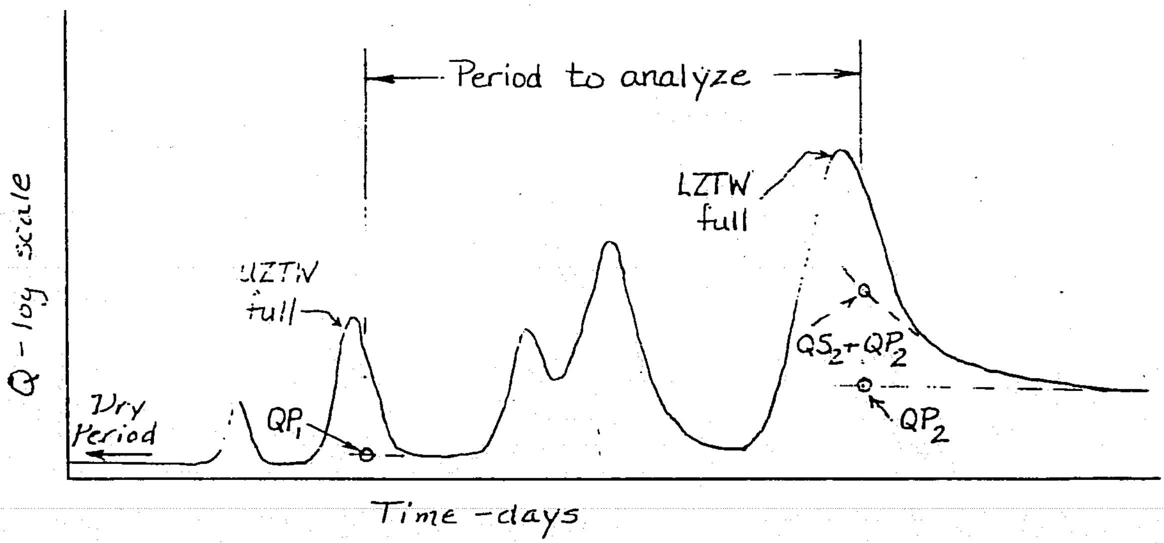
$$\text{ADIMP} = \frac{\text{Runoff Vol.}}{\text{Rain + Melt}} - \text{PCTIM}$$

Things to consider:

a. hard to determine when unit graph is long (time to peak greater than a day).

III. <u>Parameters for which initial estimates can sometimes be computed.</u>

1. LZTWM - lower zone tension water capacity.



Perform water balance on period from when UZTW fills to when LZTW fills. This period should typically be in the fall (when ET-demand is low) following a dry summer during which a large LZTW deficit was created.

Water balance equation:

$$PX - RO - R - ET = \Delta S$$

where: PX = precipitation (rain + melt),

RO = runoff,

R = deep groundwater recharge,

ET = actual ET, and

ΔS = change in soil-moisture storage.

$$\Delta S = \Delta UZTWC + \Delta LZTWC + \Delta UZFWC + \Delta LZFSC + \Delta LZFPC$$

Assumptions:

a. $\Delta UZFWC = 0.0$ (empty at beginning and end)

b. $\Delta UZTWC = 0.0$ (full at beginning and end)

c. $R = 0.0$

Computations:

a. $\Delta LZFPC = LZFPC_2 - LZFPC_1$

$LZFPC_2 = QP_2/LZPK$

$LZFPC_1 = QP_1/LZPK$

b. $\Delta LZFSC = LZFSC_2 - LZFSC_1$

$LZFSC_2 = QS_2/LZSK$

$LZFSC_1 = 0.0$

Substitution into the water balance equation gives

$$\Delta LZTWC + ET = PX - RO - LZFSC_2 - LZFPC_2 + LZFPC_1.$$

If estimate of ET can be made, then ΔLZTWC can be computed.

ET = FWS converted from daily values to period value × correction [illegible]

$LZTWM = \Delta LZTWC$

Things to consider:

a. LZTWM is probably greater than ΔLZTWC because LZTWC is seldom equal to zero at the start of the period, though LZTWC also probably overflowed for some time during the last storm.

b. the period should be kept as short as possible so that possible errors in estimating ET are small in comparisons to ΔLZTWC.

If suitable period cannot be found then estimate should be based on physical factors which are related to LZTWM. The most likely factors are root depth and climatic regime. LZTWM should be largest where roots penetrate deep into the soil and there are dry periods of sufficient length to deplete the soil-moisture to near the wilting point. LZTWM should be smallest in areas where plants are shallow rooted and there is frequent precipitation all summer.

2. UZK - interflow withdrawal rate

Can be derived similar to LZSK if:

a. permeability of soil (percolation rate) is low so that the depletion of UZFWC by interflow is much greater than by percolation.

b. unit graph peaks quickly, otherwise interflow delay and channel delay are hard to separate.

If cannot derive use nominal value of UZK = 0.3.

3. UZFWM - upper zone free water capacity

When UZK can be derived so can UZFWM.

$$\text{UZFWM} = \frac{\text{max. interflow runoff}}{\text{UZK}}$$

If cannot be derived use general estimates listed below based on how much surface runoff seems to occur.

frequency of surface RO	initial UZFWM
nearly every event	10 - 15 mm
every fairly heavy event	15 - 25 mm
only during the largest events	25 - 40 mm
never	more than 40 mm

These guidelines are only approximate since UZFWM also depends on the saturated permeability of the soil (PBASE - UZFWM < as PBASE >) and the rainfall intensities that occur during the period of record.

IV. <u>Parameters for which only the general magnitude or existence can be determined from the hydrograph</u>.

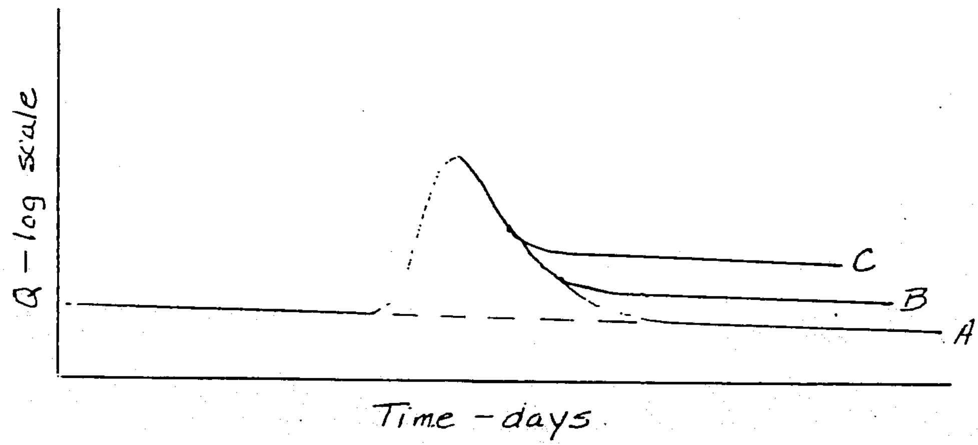
1. PFREE - fraction of percolation that goes directly to lower zone free water storages.

Conditions needed:

a. UZTWC = UZTWM

b. LZTWC < LZTWM

Under these conditions see how much baseflow recharge occurs

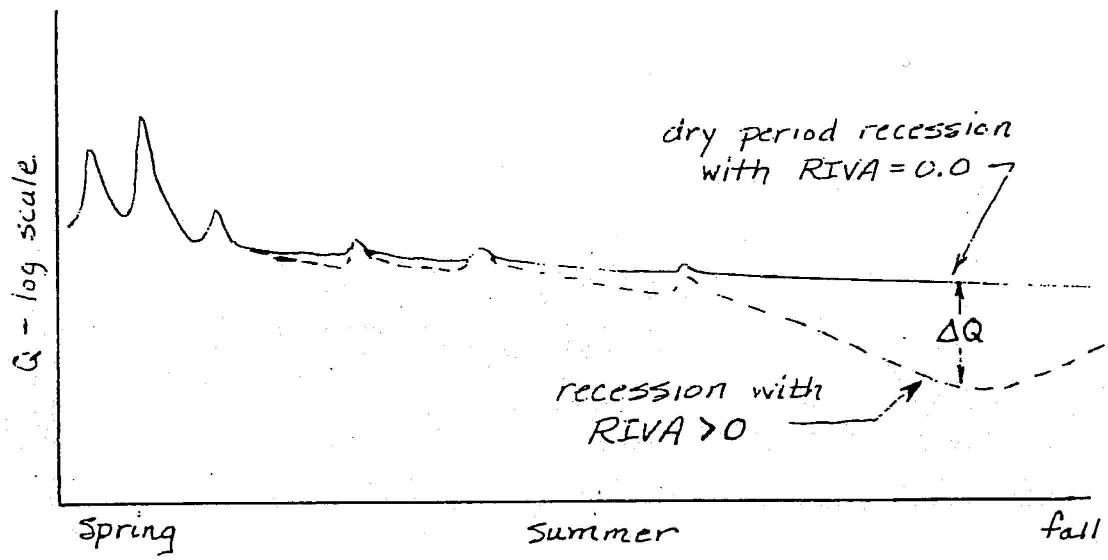


case	amt. of recharge	initial PFREE
A	little or none	0 - 0.1
B	noticeable	0.2 - 0.3
C	significant	0.4 - 0.5

2. RIVA - riparian vegetation area

The evidence that proves the existence of RIVA is a primary baseflow recession that becomes greater during dry weather periods with high ET-demand (usually dry periods during the summer). An initial estimate of RIVA could be computed, but the computation is subject to considerable error plus RIVA can be quite sensitive. Thus, usually the initial estimate of RIVA is set to zero and the actual magnitude computed later. However, it is important for the user to be aware right from the beginning whether RIVA is probably greater than zero.

Method of computation:



$$\text{RIVA} = \frac{\text{E4}}{\text{EDMND} - \text{E1} - \text{E3}}$$

where: EDMND = ET-demand,

E1 = EDMND · (UZTWC/UZTWM),

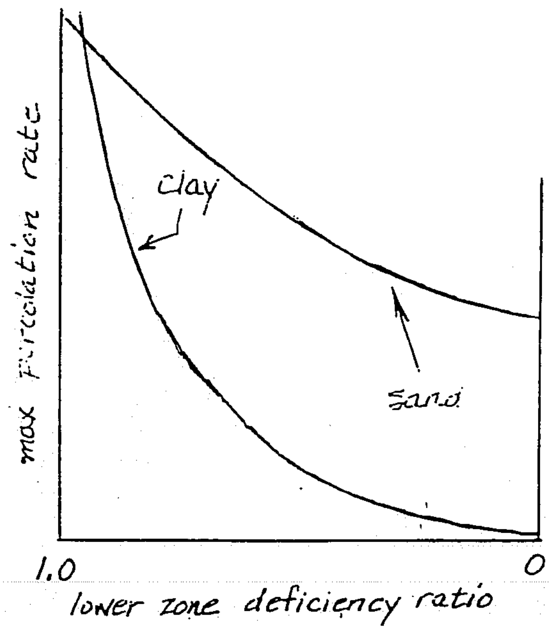
$\text{E3} = (\text{EDMND} - \text{E1}) \cdot \frac{\text{LZTWC}}{\text{UZTWM} + \text{LZTWM}}$, and

E4 = ΔQ, amount of baseflow reduction due to ET from riparian vegetation.

Computations should be made for several days - use average RIVA.

3. ZPERC and REXP - these parameters control the shape of the percolation curve and thus, the maximum percolation rate under unsaturated conditions. They should always be thought of together.

The shape of the percolation curve depends on the type of soil. The following figure shows the extremes, i.e., clay and sand.



Thus, initial estimates of ZPERC and REXP can be based on the soil type which in turn can be inferred from the hydrograph.

soil type	hydrograph characteristics	initial ZPERC and REXP
clay	lot of surface RO, little baseflow	ZPERC 75-200 REXP 2.5-3.5
silt	some surface RO, moderate baseflow	ZPERC 20-75 REXP 1.8-2.5
sand	no surface RO or only during largest events, considerable baseflow	ZPERC 5-20 REXP 1.4-1.8

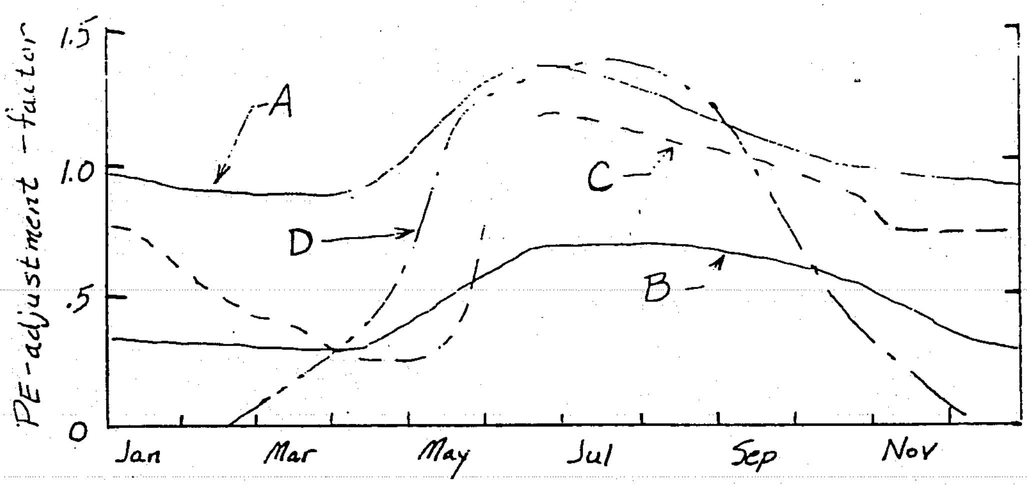
From a physical standpoint, REXP should always be greater than 1.0.

V. Parameter to estimate from physical characteristics.

PE-adjustment: ratio of ET-demand for the watershed to PE for a water surface. Depends primarily on the activity state of the vegetation. Monthly average curve is used. Implicitly included in ET-demand curve.

Mainly based on climatic regime and type of vegetation.

Examples:



A. Southern mixed forest

B. Southwest - semi-arid grassland with some forest

C. Southern Applachian highlands

D. Northern New England mixed forest

Maximum values are seldom equal to 1.0 because of biased PE data and approximations in the model equations used to compute ET, as well as because of vegetation type and climatic regime.

VI. Parameters to be assigned nominal initial values.

1. RSERV = 0.3

2. SIDE = 0.0

Could be greater than zero if so indicated by detailed geologic or groundwater recharge studies.